Biological Evaluation of the Spruce Beetle and Mountain Pine Beetle for the Brush Creek-Hayden Ranger District, Medicine Bow – Routt National Forests 2000 and 2001

Biological Evaluation R2-02-07

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Abstract

Windthrow events in 1997, 1998, and 1999 on Brush Creek-Hayden Ranger District increased the abundance of suitable host material, downed-spruce trees, for the spruce beetle, *Dendroctonus rufipennis*. Following beetle infestation and brood development in the downed trees, spruce beetles emerged and began to infest standing spruce during 2000 and 2001. Aerial and grounds surveys conducted on the district in 2000 and 2001 indicate that the number spruce beetle-infested trees increased in the Sierra Madre and Snowy Ranges. Pheromone trap data for 2000 and 2001 indicate a peak in spruce beetle flight in late June to early July with some beetle flight through the rest of the summer. A spruce beetle outbreak will likely occur in the next several years, given the number of beetle-infested standing spruce and the extensive susceptible spruce stands on the district.

The number infested lodgepole pine trees with mountain pine beetle, *Dendroctonus ponderosae*, increased on Sierra Madre and Snowy Ranges in 2001 with a large concentration of infested trees in the Upper Platte River Valley. Aerial survey estimated the number of infested lodgepole pine trees increased from 1,608 in 2000 to 13,055 in 2001. Aerial survey results suggest that the district may be in the early stages of a mountain pine beetle outbreak and may face increasing losses to this insect in the future.

Recommendations for managing the spruce beetle and mountain pine beetle on the Brush Creek-Hayden Ranger District are divided into long-term and short-term actions. Long-term actions that follow management objectives consider silvicultural treatments to manage forest stands to reduce their likelihood of infestation by creating a mosaic of age classes and stand conditions. Short-term actions include increased monitoring of beetle populations and increased efforts to eliminate currently infested trees, by killing or removing the beetles and their broods from an area. The application of insecticides to high value trees in developed recreation sites should be considered if bark beetle infestations are directly threatening them.

Acknowledgments

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Introduction

Two forest insects of major concern to the Medicine Bow Routt National Forests are the spruce bark beetle, (*Dendroctonus rufipennis* Kirby), and the mountain pine bark beetle (*Dendroctonus ponderosae* Hopkins). These two bark beetles are well adapted to the ecology of their host trees; Englemann spruce for the spruce beetle, lodgepole and ponderosa pines for the mountain pine beetle. Stands in all three forest cover types may be modified strongly during outbreaks or during larger, wide-scale epidemics of these bark beetles (Schmid and Amman 1992). The spruce beetle and mountain pine beetle have evolved with their respective hosts over long periods of time, but in very dissimilar ways based, in part, on the life history of the host trees and on the environment in which these tree species occur.

Several windthrow events occurred on the Medicine Bow – Routt National Forests, since 1997. One major event is the Routt Divide Blowdown in October 1997, primarily in the Gore Range of the Routt National Forest in Colorado, but the same wind event affected areas of the Medicine Bow National Forest (Schaupp et al. 1999). Since the original 1997 windstorm additional windthrow events occurred in the Brush Creek-Hayden Ranger District of the Medicine Bow National Forest in April 1998 and March 1999 (Schaupp 2000). Much of the windthrow was located in the spruce/fir and lodgepole pine cover types of these forests.

Windthrown Englemann spruce trees are prime habitat for spruce beetle populations to develop into outbreak status. Once spruce beetle populations reach outbreak status, they have the potential to kill standing susceptible spruce trees at a stand or landscape level. Such susceptible spruce stands and areas are located throughout the Medicine Bow and Routt National Forests (Map 1). A particularly large susceptible area is located within the Brush Creek-Hayden Ranger District, because of the older, large diameter spruce trees within these stands.

Many pine stands and areas on the Medicine Bow – Routt National Forests are susceptible to mountain pine beetle epidemics. Forest staff completed an analysis of the entire forest with respect to susceptibility to both bark beetle species that will be useful in identifying areas of concern and possible action.

Spruce Beetle

The spruce beetle is a native insect that infests all species of spruce across North America (Holsten et al. 1999). The spruce beetle has a two-year life cycle, but may complete development in one year under favorable environmental conditions. The majority of the beetle flight typically occurs in June and July. Females initiate attack on suitable hosts material and males join the females to initiate gallery construction in the inner bark or phloem of attacked trees. The female lays eggs under the bark in a gallery the first summer. The eggs hatch and develop into larvae before overwintering. The following spring and summer the larvae complete their development and pupate. The pupal stage lasts approximately two weeks. The newly developed adults overwinter, usually in the base of the infested tree and emerge the following spring or summer to infest new trees.

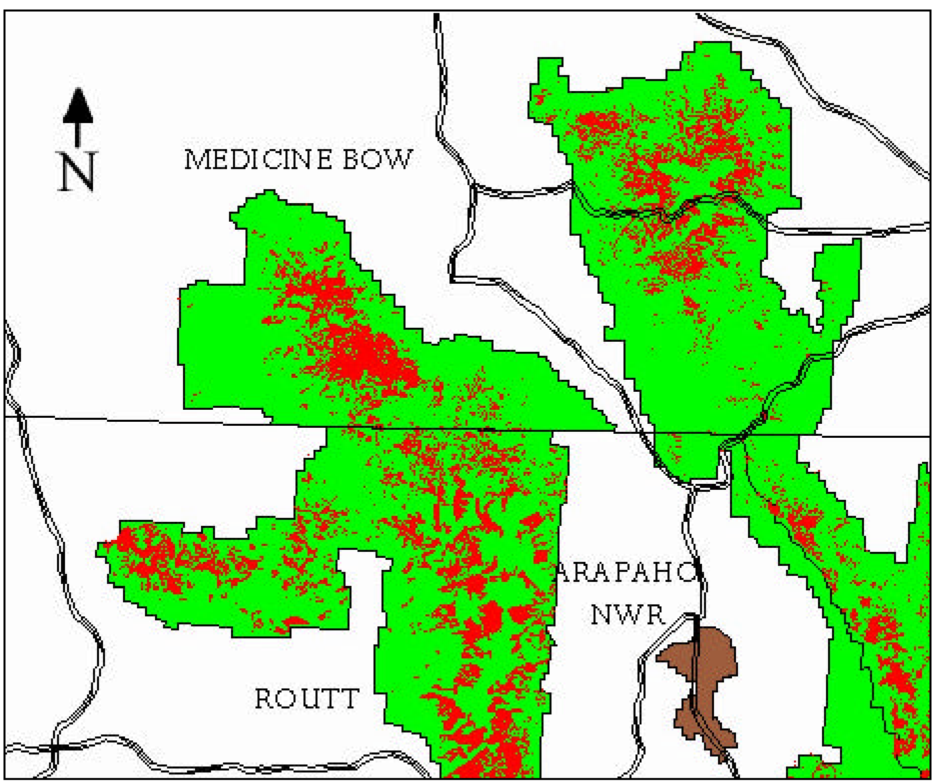
The female spruce beetles initiate attack on a spruce tree. Females produce volatile chemicals, called an “aggregation pheromone”, which are released to the air and attracts both dispersing females and male spruce beetles to the attacked tree. As females pair with males and begin gallery construction the male produces an anti-aggregating pheromone that masks the attraction of the attacked tree. The masking process of the anti-aggregation pheromone limits attack density of arriving beetles and provide adequate host substrate for the developing brood beetle larvae. Once the attack density reaches the level that masking occurs, newly arriving females and males begin to attack adjacent host trees. As a result, beetle attacks tend to appear in groups or clusters of trees rather than randomly distributed infested trees across the forest.

The spruce beetle develops to outbreak status relatively infrequently on a large spatial scale. The beetle is able to persist at low population levels in spruce forests by breeding in windthrown trees and trees dying from biotic agents, such as root diseases (Schmid and Frye

1977). As a stand ages, the spruce trees are more prone to disease and windthrow creating more favorable spruce beetle habitat. A triggering event or disturbance, such as a strong windstorm that blows over large numbers of spruce, creates conditions that lead to the rapid buildup of spruce beetle populations in the fallen trees. As broods of spruce beetles emerge from the fallen trees, they begin to attack and infest standing trees, initiating an outbreak. Epidemics develop as small spruce beetle outbreaks increase and coalesce into large areas of infested trees as the beetle continues to attack and kill more undamaged stands of spruce. An epidemic may last for many years and kill spruce over vast acreages of the cover type (Massey and Wygant 1954, Holsten et al. 1999). Residual stand structure may look very different from those that existed prior to the epidemic (Schmid and Frye 1977, Veblen et al. 1991). Recovery and regeneration of affected stands may be very slow; often spruce is replaced by subalpine fir which, over time, is replaced by spruce again as the fir dies (Schmid and Hinds, 1974). Outbreaks may be more than 115 years apart and wide-scale epidemics may be separated by 250 years or more (Veblen et al. 1994). Factors leading to outbreaks are typically disturbance of older, large diameter stands of spruce. Factors leading to the collapse of spruce beetle outbreaks usually include the depletion of susceptible spruce from the stands.

Natural enemies, including insect predators and parasites and woodpeckers, weather, competition, host tree resistance and other factors in the environment are important regulating factors when spruce beetle populations are at low density. At high density, spruce beetles outstrip the ability of natural enemies to regulate them. Under outbreak conditions, the depletion of host trees and extreme cold temperatures are the primary factors regulating populations.

Map 1. Location of spruce/fir forest susceptible to spruce mortality by spruce beetle on U.S. Forest Service land in portions of southern Wyoming and northern Colorado (Scott et al. 1993)*



*Red shaded areas indicate susceptible spruce areas.

Mountain Pine Beetle

The mountain pine beetle (MPB) is a native insect that feeds on the phloem of several pine species. It's developmental biology similar to the spruce beetle in that it completes the same life stages beneath the bark surface. Unlike the spruce beetle, the MPB typically has a one-year life cycle. Adult MPB emerge from infested trees in July and early August in Colorado and Wyoming and disperse seeking new host trees to infest.

The mountain pine beetle is the most important biotic agent of change of western pine forests (Amman et al. 1989). The beetle attacks and kills lodgepole and ponderosa pines when trees within the stands reach diameters favored by the beetle. Mountain pine beetle populations persist at low densities by infesting single trees that have been damaged by lightning or are diseased (Schmid and Mata 1996). Outbreaks tend to occur at intervals of fifteen to twenty years in older pine forests in the Rocky Mountains and may last for six to ten years in lodgepole pine (Cole and Amman 1980). In ponderosa pine, outbreaks may last from 2 to 5 years and epidemics may last for 7 to 14 years (Blackman 1931, McCambridge et al. 1982). Over longer periods of time, multiple outbreaks occur across a landscape of mature forests, renewing the forest cover at intervals between 50 and 100 years (Schmid and Amman 1992). Fire often facilitates the renewal and regeneration of pine forests following major mountain pine beetle outbreaks. Factors leading to outbreaks are not well understood, but are related to an increase in the number of trees exceeding 8 inches diameter at breast height (DBH). Factors leading to the collapse of a mountain pine beetle outbreak are related to the depletion of trees greater than 8 inches DBH, unfavorable weather, natural enemies, and other influences.

Unlike the spruce beetle, MPB outbreaks are not triggered by a major disturbance, such as windthrown trees. MPB outbreaks are mostly related of trees stressed from damage, overcrowding, and/or age. The typical stand where a MPB outbreak may develop will consist of well-distributed, large diameter trees or in dense stands of pole-sized ponderosa pine (Amman et al. 1989). Lodgepole pine stands that are susceptible to MPB typically have the following characteristics: average diameter at breast height (DBH) > 8 inches; average age > 80 years; and a suitable climate for beetle development usually below 9,500 feet for southern Wyoming (Amman et al. 1977, Schmid and Amman1992). Stand susceptibility ratings have already been calculated or interpolated for stands on the Brush Creek-Hayden Ranger District. Many of the stands are at risk of over 50% mortality should an MPB outbreak occur there.

Purpose

The purpose of this Biological Evaluation is to document the occurrence of spruce and mountain pine beetle infestations on the Brush Creek-Hayden Ranger District and to provide management recommendations to the District for these two bark beetles.

Materials and Methods

Several actions have been taken by Forest Health Management (FHM) and the Brush Creek-Hayden Ranger District staff to monitor bark beetle populations on the district. These actions include aerial survey, pheromone funnel traps, and ground surveys in and near recreational areas.

Aerial Survey

Aerial surveys were conducted from a fixed wing, single engine aircraft at about 1,500 ft. above the ground at approximately 100 miles during the summer of 2000 and 2001. Erik Johnson (Aerial Survey Program Manager, FHM) with assistance from Willis C. Schaupp, Jr. and Lee Pederson performed the aerial surveys. Recent tree mortality and new windthrow was recorded onto 1:100,000 scale US Geological Survey 30 X 60 minute maps. Identifying newly infested spruce trees from the air is difficult, because the trees do not fade from spruce beetle attack until the following year. Even then, the dead spruce needles fall off the tree so the tree continues to look green until all the needles fall off. Aerial surveys provide trends and approximate location information that facilitates ground surveys, but does not convey the exact numbers of infested or diseased trees.

Pheromone Funnel Traps

Two 16-funnel Lindgren traps baited with a two-component attractant (frontalin and alpha-pinene) were placed near the Lost Creek Campground (T14N, R86W, NW ¼ of Sec. 33; elevation 8,800 ft). These traps were monitored by Brush Creek-Hayden Ranger District staff from June 15 through September 1, 1999.

For the 2000 and 2001 monitoring, adjustments were made to the locations and numbers of traps deployed. Four Lindgren traps baited with the attractant were placed on the Brush Creek-Hayden Ranger District to monitor the spruce beetle. Two traps were located in the Sierra Madre Range within the Haskins Creek Houselog Timber Sale (T14N, R86W, NW ¼ of Sec. 34; elevation 9,000 ft.), and the other two traps were located in the Snowy Range just east of the junction of Forest Service Roads (FSR) 103 and 103.1H (T16N, R80W, SW ¼ of Sec. 14; elevation 10,400 ft.). The Haskins Creek traps were monitored, weather permitting, in 2000 from June 5 through September 1, and in 2001 from May 31 through September 18. The Snowy Range traps were monitored, weather permitting, in 2000 from July 5 through September 1, and in 2001 from June 2 through September 4. The traps were checked weekly from May through the end of July, then from August to the end of the trapping season the traps were monitored every other week. The spruce beetle attractant and traps were obtained from Pherotech, Inc. (Delta, B.C. Canada).

General Reconnaissance and Ground Survey

General reconnaissance and ground surveys were conducted at five areas in the Medicine Bow National Forest by FHM and Brush Creek-Hayden Ranger District staff during August and the first week of September 2001. This was a follow up to an earlier survey (Schaupp 2000).

In the Sierra Madre Range, surveys were conducted in the Haskins Creek Houselog Timber Sale and Lost Creek Campground areas along WY State Highway 70. The area surveyed as Lost Creek Campground, north of WY State Highway 70, included the campground and a ¼ mile buffer to the north and east of the campground. The Haskins Creek Houselog Timber Sale survey area, south of WY State Highway 70, included the cutting unit ITM 4 and a ¼ mile buffer around the cutting unit. The number and placement of infested trees at each location were recorded, as well as the stage of the bark beetles.

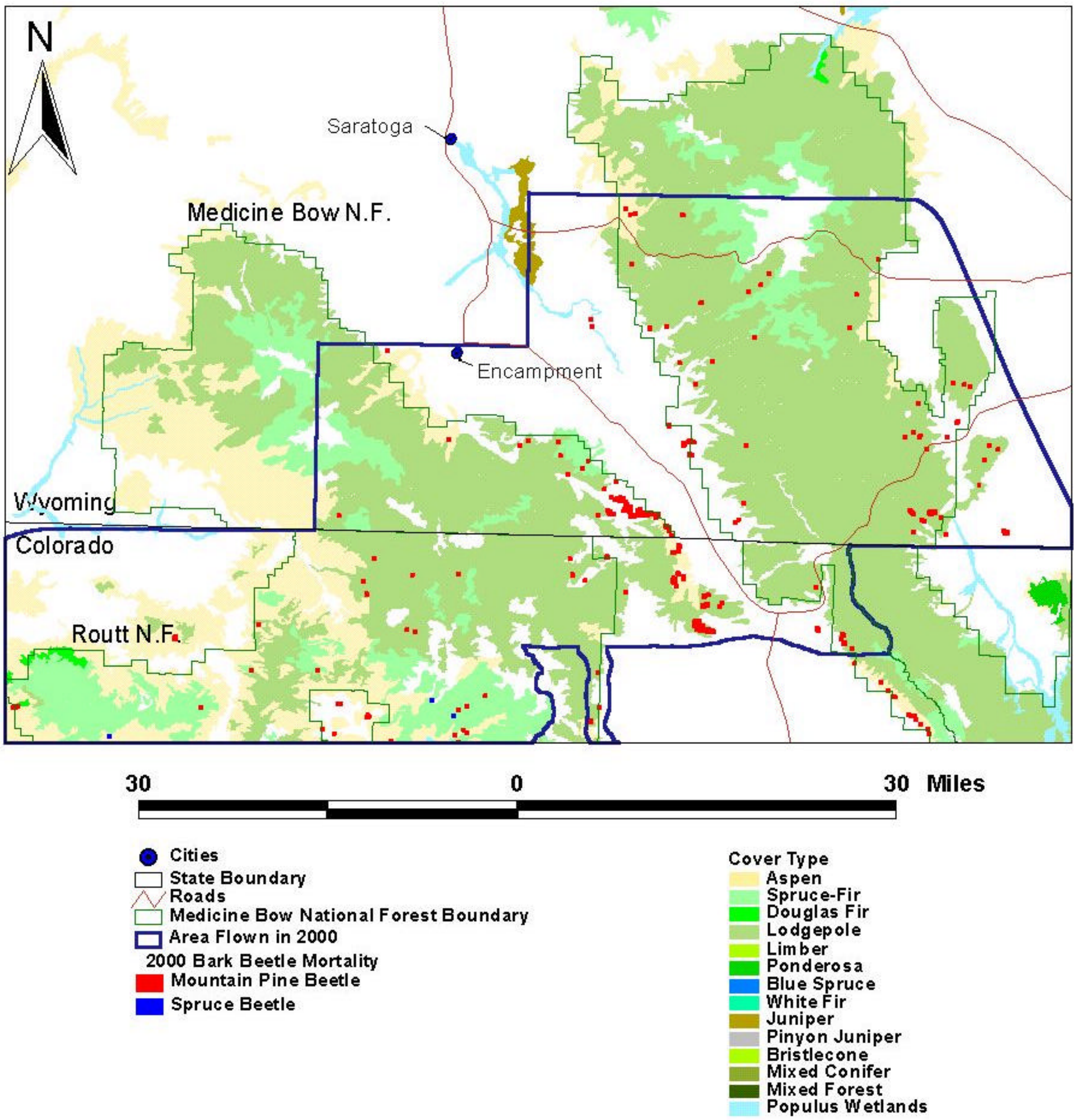
In the Snowy Range, areas surveyed consisted of the Road 103 blowdown, Silver Lake Campground, and North Twin Lake. Road 103 blowdown was approximately 3 acres in size and was just west of FSR 103, approximately ¼ mile north of WY State Highway 130. The North Twin Lake area surveyed was a ¼ mile area around the lake. The Silver Lake Campground survey area consisted of the campground and a ¼ mile buffer around the campground. The number and placement of infested trees at each location were recorded, as well as the life stage of the bark beetles.

Results

Spruce beetle

The 2000 aerial survey did not indicate any areas of spruce mortality caused by spruce beetle for the Sierra Madre and Snowy Ranges on the Medicine Bow National Forest for the area flown (Map 2). The only spruce beetle activity indicated on Map 2 is on the Routt National Forest.

Map 2. Aerial survey of bark beetle activity in 2000 Medicine Bow National Forest



The 2001 aerial survey indicated an estimated 118 trees of spruce beetle-caused mortality in the Sierra Madre Range, which was an increase from 2000 when no trees were detected (Map 3). To parallel this situation, the aerial survey indicated four locations on Hahns Peak/Bear Ears Ranger District of the Routt National Forest that totaled an estimated 11 trees of spruce mortality in 1999, and nearly 12,000 trees killed by spruce beetles in 2001 (Schaupp et al. 2002). As a reminder, the spruce mortality indicated by aerial survey is at least one year behind what is happening on the ground, because the trees do not begin to fade until the following year.

In 1999, a total of 17 beetles were caught in the two traps at the Lost Creek Campground with most being caught in July. Similarly, there was a peak in spruce beetle flight activity in late June for 2000 and a peak in early July in 2001 indicated by the pheromone traps (Figure 1). Although most of the beetle activity was in late June and early July, there continued to be beetle activity until the third week of September during 2000 and 2001 at the Haskins Creek site. The beetle activity described on the Routt National Forest is similar to the beetle activity on the Medicine Bow National Forest with a peak in late June or early July, and continued activity throughout the rest of the summer (Schaupp et al. 2002).

Spruce beetle infested trees were found at all of the survey areas (Table 1). Within each area, the infested trees had combinations of spruce beetle adults, eggs, larvae, and pupae. Most of the infested trees were found around the North Twin Lake, Road 103 blowdown, and Silver Lake Campground areas. Some of the trees in these areas were infested with only spruce beetle adults. Trees infested with adults only were either recently infested, or newly developed brood adults that will be flying and infesting more trees in 2002. Many of the down trees in the North Twin Lake area had adults that are expected to emerge the following summer and attack neighboring spruce trees.

Mountain Pine Beetle

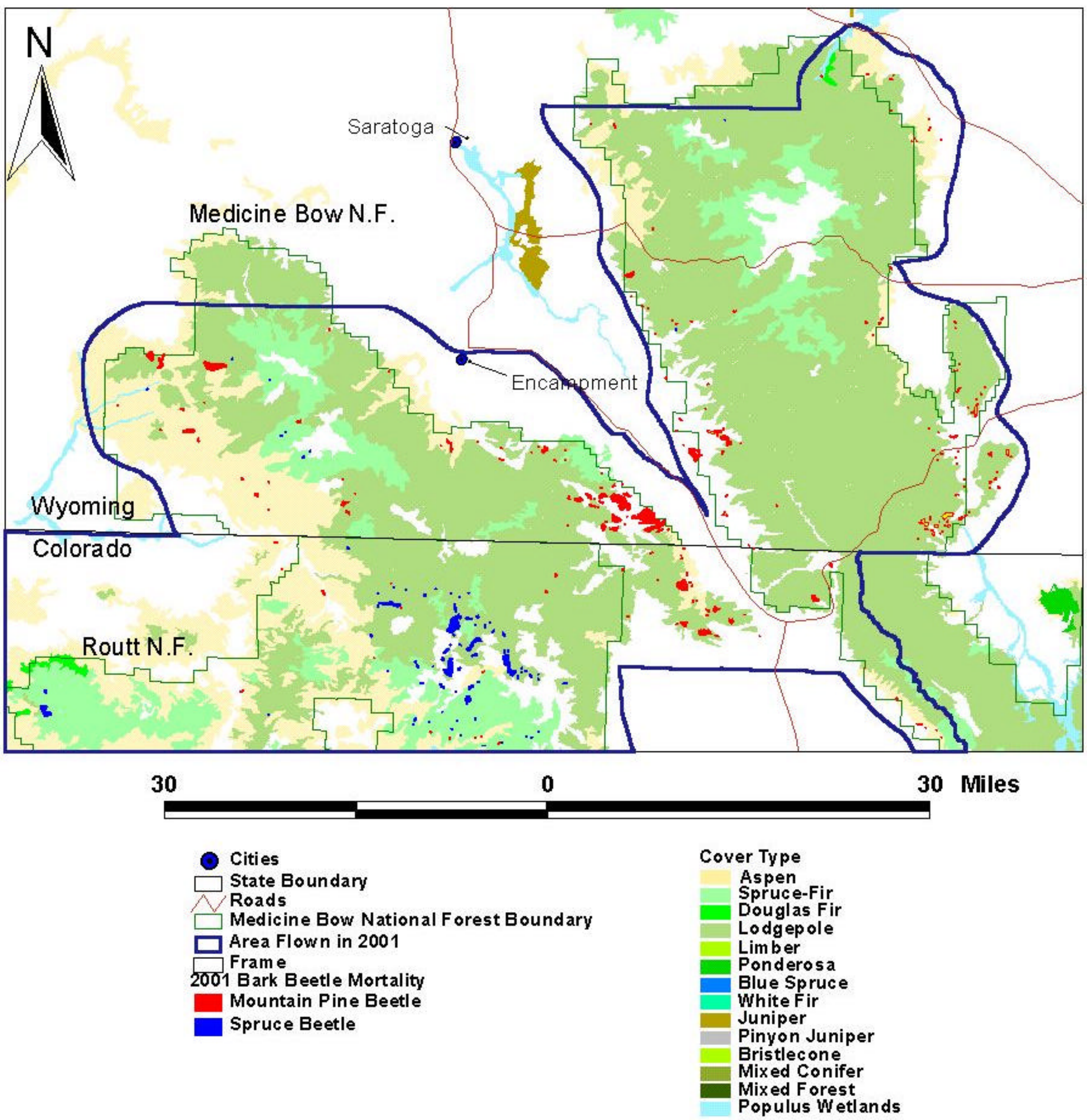
Results from aerial survey indicate an increase in MPB activity on the Sierra Madre and Snowy Ranges between 2000 and 2001, from an estimated 1,608 infested lodgepole pine trees to approximately 13,055 trees, respectively (Table 2). Much of the MPB activity was southeast of Encampment, WY near the Wyoming and Colorado border on public and private lands in the Upper Platte River Valley for both years (Map 2 and 3). There are also scattered MPB infested stands in other parts of the Sierra Madre and Snowy Ranges. It is important to note that not all of the Medicine Bow on the Sierra Madre and Snowy Ranges were flown during the 2000 and 2001 aerial survey.

Although the ground surveys were conducted primarily for the spruce beetle, some MPB infested lodgepole pine trees in Lost Creek Campground and in the Haskins Creek houselog timber sale were found (Table 1).

2001 Suppression Accomplishments

The district staff brought in a crew of seven highly skilled sawyers to treat spruce beetle infested trees. The crew felled and peeled 24, 36, and 30 trees in Silver Lake Campground area, Lost Creek Campground area, and Lost Creek Timber Sale, respectively in October 2001. Also, 31 trees were added as additional volume to the Haskins Creek Houselog Timber Sale that were removed in September 2001. These treatments were a result of survey and suppression activities begun in 2000.

Map 3. Aerial survey of bark beetle activity in 2001 Medicine Bow National Forest



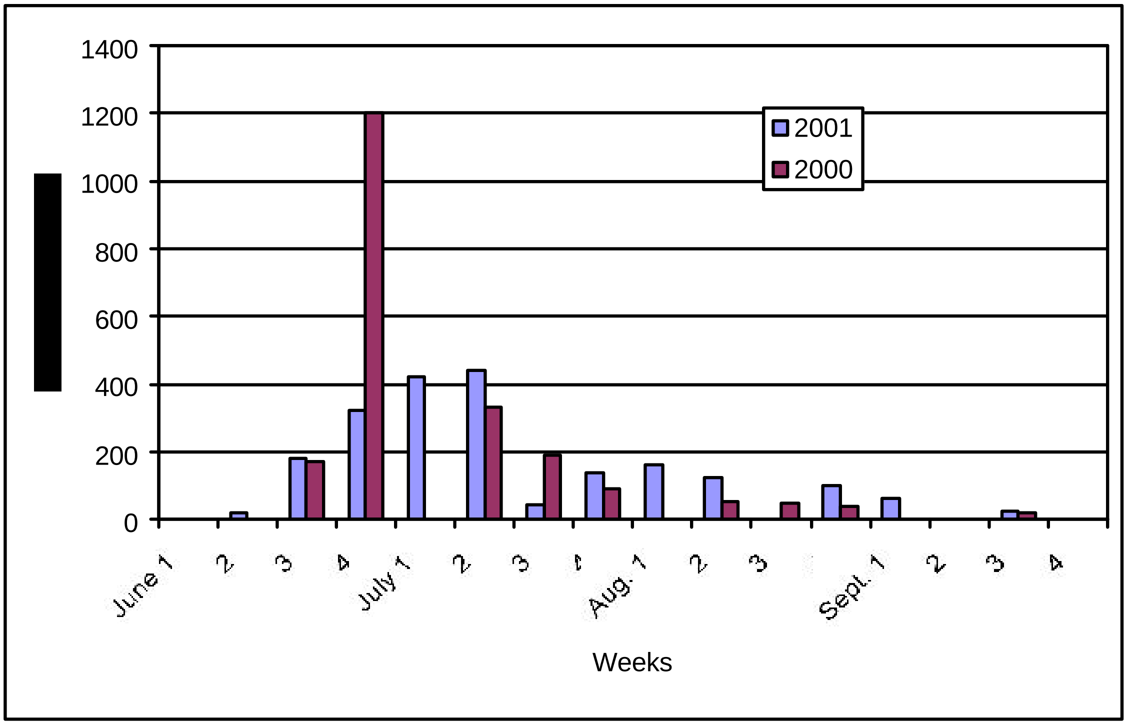


Figure 1. Weekly total number of spruce beetles caught in 2000 and 2001 for the pheromone funnel-traps on the Medicine Bow National Forest.

Table 1. Number of bark beetle-infested lodgepole pine and Engelmann spruce trees within the survey areas of the Brush Creek-Hayden Ranger District on the Medicine Bow National Forest in 2001.

Survey Areas	Mountain Pine Beetle Infested Lodgepole pine		Spruce Beetle Infested Engelmann spruce	
	Standing	Down	Standing	Down
Silver Lake Campground Area	0	0	30	4
North Twin Lake Area	0	0	24	~80*
Road 103 Blowdown Area	0	0	19	46
Lost Creek Campground Area	5	0	31	0
Haskins Creek Houselog Timber Sale Area	7	1	16	1

* Includes 40-50 blowdown spruce trees suspected to be infested, but not surveyed because of time constraints.

Table 2. Estimated acres and number of lodgepole pine trees affected by mountain pine beetle as indicated by aerial survey for the area flown on the Sierra Madre and Snowy Ranges of the Medicine Bow National Forest in 2000 and 2001.

Year	# of Trees	# of Acres
2000	1,608	998
2001	13,055	6,495

Discussion

Outbreak status in standing trees

The spruce beetle populations are increasing on the Brush Creek-Hayden Ranger District. Spruce beetle populations have exited some of the windthrow and are now attacking and killing standing spruce trees. This suggests that the spruce beetle population may be approaching outbreak status in these areas. The 2001 aerial survey indicates an increase of infested spruce, but the aerial survey does not pick up currently infested spruce. The number of spruce beetle-killed trees indicated by aerial and ground survey can be expected to increase in the Sierra Madre and Snowy Ranges of the Brush Creek-Hayden Ranger District over the next several years, if it follows a similar pattern to the spruce beetle epidemic on the Routt National Forest (Schaup et al. 2002). This increase of infested spruce trees may continue for the next several years, because of the large area of susceptible spruce on the District (Map 1). Efforts to locate beetle populations in areas of high value and remove them quickly should be a priority for the District.

Areas that were not previously ground surveyed or monitored by pheromone funnel traps for the spruce beetle that should be considered for 2002 include the French Creek Campground for the Snowy Range; and east of Silver Lake Campground in the Sierra Madre Range. These areas may be of concern because of their close proximity to spruce beetle mortality identified by the aerial and ground surveys in 2001.

Pheromone traps are currently the best technique for detecting and monitoring bark beetle flight activity. The pheromone trap data from 2000 and 2001, and subsequent years should provide a better indication of beetle flight activity for attacks on standing trees. In 1999, many of the spruce beetles most likely re-infested blowdown and did not seek standing trees to attack, resulting in few beetles being caught by the pheromone traps that year. The absolute numbers from the pheromone traps are not a good indicator of population size, but when relatively many beetles are caught the assumption could be that a large population was dispersing at that time. Whereas, if there were few beetles caught in the pheromone traps one could make the assumption that a smaller population was dispersing at that time.

MPB population appears to be increasing on Sierra Madre and Snowy Ranges, because of the increase in MPB tree mortality from the aerial survey. Along WY Highway 230 southeast of Encampment near the Wyoming and Colorado border on the Sierra Madre Range the Big Creek Drainage had much of the MPB activity for the Brush Creek-Hayden Ranger District. Other areas of concern for MPB mortality on the Sierra Madre Range include the Big Sandstone Creek area. For the Snowy Range, lodgepole pines within the Lake Owen, Pike Pole and Pickaroon Campgrounds may be of concern. These areas are mentioned because of their close proximity to MPB associated mortality identified by the aerial survey. One timber sale has been prepared and others are planned to address the MPB activity in the Upper Platte River Valley. These silvicultural activities will likely reduce possible negative impacts of MPB at those sites.

Potential risks of adjacent forested lands

The potential for spruce beetle outbreaks exist within the Brush Creek-Hayden Ranger District, because two important conditions exist: large area of susceptible spruce trees and an abundance of spruce beetles. Recent blowdown events and susceptible forests in Wyoming and other parts of Colorado are facilitating spruce beetle outbreaks across the region, especially adjacent to the assessment area in the Hahns Peak/Bears Ear and Parks Districts of the Routt National Forest (Schaupp et al. 2002). The bark beetle epidemics have the potential to reach landscape scale and kill most of the older mature spruce over the west slope of the Rocky Mountain Region over the next 10-15 years.

In the 1940's this drama played out in the Flat Tops Wilderness, White River, Arapaho/Roosevelt, and Routt National Forests, before a rare, extremely cold temperature episode stopped the outbreak. Consequently, this same area is not highly susceptible to spruce beetle mortality now (Schaupp et al. 2002). The spruce forests of northern Colorado and southern Wyoming were susceptible to spruce beetle outbreaks in the late 1940's and is probably more susceptible now, some fifty years later. The district will not be able to stop a large-scale spruce beetle or a mountain pine beetle outbreak once it develops. However, the district may be able to protect high value areas or individual trees from being killed by the bark beetles with suppression and silvicultural actions.

Recommendations

There are short-term and long-term management strategies for treating bark beetle populations. Prioritizing areas by management objective is important when addressing bark beetle management to optimize actions to protect areas of interest. Prioritizing areas will help determine the appropriate management tactics for a given area.

Long-term management strategies for bark beetles rely on silvicultural tools to produce stands that are not susceptible to bark beetles. A long-term goal of reducing susceptibility to bark beetles involves creating a mosaic of age classes and stand conditions across the forested landscape. There are many variations to the silvicultural treatments that are discussed in Appendix 1 for the spruce beetle and Appendix 2 for the MPB. Because landscape-scale beetle epidemics are infrequent, the opportunity exists to modify stand and landscape conditions in areas where beetle-caused disturbances conflict with management objectives. It is recommended that the district undertake an integrated overview of the bark beetle situation as it exists now, consider desired future conditions, and do so in a way that considers all susceptible forested lands.

Short-term management tactics, such as trap trees (only for spruce beetle), pheromone traps, direct suppression and preventative spraying address the symptom of the problem --- too many beetles in one place at one time. Some adjustments can be made to the short-term management tools to maximize their effectiveness in areas of concern. Trap trees work best in an area where there are known spruce beetle populations. If the trap trees are not positioned in shaded areas *Ips* beetles may overwhelm the trap tree making it undesirable for the spruce beetle. One option in many areas may be the use of lethal trap trees in and around areas of known beetle populations. The lethal trap trees will be more efficient in killing spruce beetles, because the *Ips* and the spruce beetles will be killed as they try to enter the trap tree.

Trapping beetles with pheromone funnel traps should be continued and expanded across the forest to monitor the spruce beetle activity in areas of concern. In addition to the Haskins Creek and Lost Creek sites, monitoring the French Creek Campground will likely be necessary in 2002 for the spruce beetle. Aggressive trapping efforts in an area may have the potential to reduce local outbreak impacts on the forest (Bentz and Munson 2000).

Pheromone trapping will help determine when survey and suppression efforts should begin, which is expected to be in mid July after the peak of spruce beetle flight activity. Ground surveys should not begin until after peak flight has occurred. If ground surveys are conducted before the peak in beetle flight, the surveys may underestimate the number of trees infested, because trees may continue to be attacked by beetles after the survey is completed. Even if a survey is completed after the peak in bark beetle activity, additional trees may be attacked in an area, because the beetle activity continues to a lesser extent throughout the summer. Additional years of pheromone trapping data will give a better indication of how long the beetle flight period is, and when it typically begins. After a ground survey is completed for an area, suppression treatment of infested trees or beetle habitat should be completed before snowfall restricts access. During the suppression treatment the infested bole, the root collar, and any exposed roots of the tree should be treated. This should reduce the pheromone plume produced by the beetles that attracts other beetles to the infestation. Reducing the pheromone attraction plume should be a major concern in high value areas because it will reduce the number of beetles immigrating to that area.

Areas that were ground surveyed in 2001 should be ground surveyed in 2002 for effectiveness of 2001 treatments and monitor current infestations, as well as some additional areas of concern should be ground surveyed. Additional areas may include the French Creek Campground for the spruce beetle and Upper Platte Valley for MPB.

Removing currently infested trees may be a short-term solution to a bark beetle outbreak within a stand. Only removing infested trees will not modify the stand characteristics enough to change the stand from a susceptible condition to a non-susceptible condition. However, treating all known infested trees in an area may reduce the pheromone plume and reservoir of beetles to help prevent future infestations or prevent the current infestation from progressing to an outbreak.

The district may need to consider preventative insecticide treatment for trees in high value areas where bark beetle infestations are a threatening developed areas. Preventative spraying of trees in the high value areas, especially in campgrounds, may be necessary to keep trees from being attacked and killed by the bark beetles. Preventative spraying of trees must be completed before the beetle flight period to be effective. When applying a preventative insecticide, treat the bole (as high as possible), the root collar, and any exposed roots.

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APPENDIX 1: ACTION ALTERNATIVES FOR MANAGING SPRUCE BEETLE IMPACTS

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MANAGEMENT STRATEGIES

Forest managers can develop various strategies to avoid or reduce resource losses to spruce beetles. Before developing a strategy, the forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered, because population levels will determine the priority of management actions and the type of strategy to be invoked. Landscape considerations are important, because both stand susceptibility and beetle population levels in adjacent and nearby stands will influence bark beetle caused tree mortality in stands under consideration.

The primary strategy should be silvicultural treatments of potentially susceptible stands in order to maintain their health with a moderate growth rate. These silvicultural strategies should be implemented well in advance of an epidemic. The first step in this strategy is to risk-rate spruce stands, which will indicate the most susceptible stands and areas where susceptible stands are concentrated. The stands can then be treated with harvesting directed at the most susceptible stands and areas. Infested logging residuals seldom become a significant contributor to spruce beetle populations if stump height is kept below 18 inches (45 cm) and cull logs and tops are limbed, cut into short lengths, and left unshaded, unpiled, and exposed to sunlight. Silvicultural treatments have greater long-term effectiveness, because these treatments modify stand conditions.

The primary strategy assumes, in general, beetle populations are not immediately threatening resource values. If beetle populations are threatening, then strategies involving suppression are more appropriate. Suppression methods including silvicultural, physical and chemical measures are available to forest managers for reducing spruce beetle populations. Some methods are suitable only for populations in windthrown host material; other methods are better suited for infestations in standing trees. Most suppression methods are short-term responses to existing beetle populations and, therefore, correct only the immediate situation (Holsten et al. 1999).

A long-term goal of reducing susceptibility to spruce beetle involves creating a mosaic of age classes and stand conditions across entire landscapes. Without substantial interference, each major spruce beetle epidemic sets the stage for the epidemic to be repeated, as the forest regenerates and grows again into a susceptible condition. Because landscape-level spruce beetle epidemics are infrequent, the opportunity exists to modify landscape conditions in areas where these large beetle-caused disturbances conflict with management objectives. In this way, major spruce beetle epidemics may not necessarily be repeated in the distant future.

TREATMENT OPTIONS

SILVICULTURAL TREATMENT

Silvicultural practices and priorities can be developed if clear and well-defined management objectives exist. In determining treatment or cutting unit priorities, spruce beetle susceptibility should be integrated with all the other treatment objectives to best attain management goals and objectives. Three stand ratings, utilizing the potential outbreak rating or risk, provide guides that should be used in determining overall stand treatment priorities.

1. High. Susceptibility to attack and damage is a primary concern in reaching or maintaining management objectives where the potential spruce beetle risk is high or medium. This concern may be addressed by evaluation of probable spruce beetle population trends, possible impacts, and so forth, conducted by pest management specialists. In the event of an outbreak, a majority of spruce in the larger diameter classes (> 12 inches DBH) will be killed.

2. Medium. Susceptibility to attack and damage is a concern in attaining management objectives, but is definitely less than in high rated stands. The degree of concern will depend upon management objectives for the area and how a potential spruce beetle outbreak might affect them.

3. Low. Susceptibility to attack and damage by spruce beetle is not a concern.

An important consideration in any silvicultural treatment is wounding of residual trees. Great care must be exercised in any mechanical entry to avoid wounding. Especially with sub-alpine fir and, to a lesser degree, spruce species, as wounds provide entry courts for decay and root disease fungi. Not only can the pathogens lead to tree mortality, it is likely that there is an interaction between spruce beetle and infected trees, rendering them more susceptible to beetle attack.

Cutting Methods in Susceptible Stands

Once a spruce beetle infestation reaches epidemic proportions in susceptible stands, chances for control are greatly reduced. Hence vegetation management strategies aimed at preventing the accumulation of numerous high-risk stands and other high-risk beetle situations are the preferred management approach.

Intermediate Cutting Methods

A. Sanitation/Salvage. During an outbreak, beetle infested, dead, and highly vulnerable large diameter spruce are removed in an effort to maximize utilization of attacked material. Salvage of significant blowdown material within 1 to 2 years, particularly when it occurs in and adjacent to highly susceptible stands, is recommended where it meets overall management objectives.

B. Presalvage. With the imminent threat of an outbreak, large diameter, slow growing spruce are removed from highly susceptible stands. Presalvage is the removal of merchantable trees in anticipation of losses likely to occur before definitive regeneration cuts (Smith 1986). In some situations, presalvage may achieve the same results as a shelterwood cut.

C. Precommercial thinning. Thinning young stands to regulate stocking and species composition may be appropriate when commensurate with other stand objectives.

D. Commercial thinning. Thinning at 20 or 30 year intervals will improve stand vigor. While thinned stands have higher average diameter, benefits from improved vigor likely outweigh risks associated with having larger diameter trees. Thinning pine stands susceptible to mountain pine beetle indicates that the habitat modification provided by thinning is an important contributor to reduced stand susceptibility. Spacing between trees is the critical factor in this, rather than just reducing tree density. It is likely that habitat modification in thinned spruce stands would play a similar role of reducing stand susceptibility to spruce beetle. However, windthrow is a significant concern when increasing inter-tree spacing. A long term goal of thinning more appropriate to spruce/fir stands may be to create a mosaic of age classes rather than trying to maintain a single age class.

Even-aged Regeneration Cutting Methods

A. Clearcutting. This method effectively eliminates bark beetle risk on treated acres for a considerable period of time. However, if faced with large acreages of unmanaged, highly susceptible stands, clearcut regeneration techniques will require decades to achieve a level of management where beetle risk is diminished. Where locations have a mix of low, medium, and high-risk stands, clearcutting the high risk stands over one or two decades may diminish the overall beetle risk. Regeneration needs will significantly affect the location and degree to which this method is employed.

B. Shelterwood. This method has advantages over clearcutting when an objective is to reduce beetle susceptibility within a location in a minimum of time. For a given sale quantity, shelterwood cuts would require treatment of more acres than clearcutting. Shelterwood prescriptions should provide opportunities to remove trees at high risk to bark beetle, such as damaged trees, trees already infested, or poor vigor dominants and codominants. Where more than the recommended basal area to be removed is in high risk trees, a decision of whether to accept the risk of spruce beetle attacks or to accept the risk of windthrow by removing additional susceptible trees will have to be addressed (Alexander 1986). Two or three entries may be required to meet the desired condition (Alexander 1986).

Uneven Aged Regeneration Cutting Methods

In situations where stands are clearly irregular in structure, maintaining the irregular stand structure is desirable, and the risk to spruce is apparent and undesirable, selection or group selection cutting methods are applicable. Selection regeneration methods may have advantages in managing spruce beetle susceptible stands in these situations by allowing regulation of stocking, basal area, and controlling diameter distribution while maintaining stand characteristics valuable to management objectives.

No specific information or guidelines are available on the implementation of uneven-aged cutting methods in spruce beetle susceptible stands. Multiple entries may be required to achieve the desired stocking and diameter distribution. However, where visual quality is important, suggested stand structure objectives could be a growing stock level of 100 to 120 sq. ft. of basal area on most sites, a maximum tree diameter of 24 inches, and a diameter distribution approaching a Q of 1.3 to 2.0 (Alexander and Edminster 1977). Where lowered susceptibility to spruce beetle is needed, fewer large diameter trees are desirable, so that an average stand diameter less than or equal to 12-14 inches for spruce is suggested. As with commercial thinning, the improved stand vigor and modified habitat conditions which would result from cutting in uneven aged stands is predicted to lower stand susceptibility to spruce beetle attack and tree killing.

Minimizing Spruce Beetle Build-up in Logging Slash and Debris

The following guidelines can be utilized to minimize spruce beetle population increases in logging slash and debris:

A. Cut trees as low to the ground as possible, preferable stump height of no more than 12 inches.

B. Cull logs and larger diameter slash material can be used to "trap" beetles to further reduce populations and lessen the risk of attack to standing trees, if this material is left in the cutting unit and then removed or treated after beetle flight. This trap material must be removed prior to the next beetle flight. If they are not removed, beetles produced in this material will increase the chance of attacks to surrounding standing spruce (Schmid 1977). Utilize C-Provisions, R0-C-6.46, R0-C6.47, R0-CT-6.46, and R0-CT-6.47 as deemed necessary.

CULTURAL TREATMENT

Trap Tree Method

Trap trees are green trees with a diameter greater than 18 inches DBH that are felled, preferably before the spring beetle flight (Holsten et al. 1999). Trap trees should be left in their "natural state" with no limbing being done, because the limbs shade the bole and make the trees more attractive to spruce beetles. Trap trees are used to attract and decoy emerging beetles away from living, standing green spruce trees. Traditional trap tree usage is more effective for absorbing beetles than baiting standing green trees for the following reasons: 1) beetles prefer downed material over standing green trees; 2) beetles infest a greater percentage of the bole; and 3) the mean attack density is greater. Once the trap tree is infested with beetles, it must be treated by milling, burning, solar heating, or insecticidal application (Schmid and Frye 1977).

Trap tree treatment considerations to be aware of are as follows: 1) beetles are effectively attracted up to one-quarter mile from the felled tree, becoming less effective with an increase in distance; 2) trees felled in the shade are preferred over those felled in the sun (Nagel et al. 1957); and 3) trap trees, by attracting beetles, may lead to attacks on standing spruce adjacent to them. Unbucked trees provide more shade, increasing beetle suitability and reducing both fungal development and competition from *Ips* species, because branches provide increased shade and serve to hold the bole above ground. By keeping the bole off the ground, more of the shaded underside is available for colonization. The number of trap trees felled is relative to the attacking beetle population and the size of the felled host. A trap tree may absorb 10 times the number of beetles a standing tree will absorb (Schmid and Frye 1977). Nagel et al. (1957) recommends one trap tree for every four to five infested standing trees. Schmid and Frye (1977) include a table for more precise estimates of the number of trap trees to be felled based on the current infestation level.

Sanitation of Infested Trees

This treatment strategy does not differ in principle from silvicultural treatments where trees currently infested by spruce beetle are removed or treated to kill the beetles within them. In practice, this treatment differs from silvicultural treatments in that fewer trees are removed and mechanical means may or may not be used. Prompt identification and treatment of infested trees before the inhabiting beetles emerge will remove a local source of contagion. It can afford a degree of protection to nearby susceptible trees and stands. Consideration must be given to the relative susceptibility of the adjoining landscape and the local “beetle pressure.” Where both are at a high level, sanitation of a few infested individual trees is not likely to have a positive benefit due to immigration of beetles and because the number of trees removed may not alter susceptible stand conditions.

CHEMICAL

Lethal Trap Tree Method

Lethal trap trees, a modification of the traditional trap tree method, are another effective option to attract, hold and eliminate beetles from the forest (Frye and Wygant 1971, Buffam 1971, Buffam et al. 1973, Lister et al. 1976). Lethal trap trees eliminate the need to remove infested material from the forest and can be especially useful in areas where removal of material is prohibitive. Prior to felling, the trap tree is injected with a silvicide, making it a lethal trap tree. Currently, no silvicides are registered for use in the United States.

A variation of the lethal trap tree method is to apply an insecticide to the felled trees so that attacking beetles are killed as they attempt to bore into the treated tree. Currently, several insecticides are registered and available for this use in the United States.

Insecticides Preventing Infestation

Insecticides can be applied to the boles of uninfested trees to kill attacking beetles and protect high value trees. Application of these insecticides will not kill larvae or adults already present in the phloem. These insecticides work directly on the attacking adults attempting to bore into the tree and therefore need to be applied prior to the tree being attacked by spruce beetles. Only insecticides labeled for this use can be applied. Pruning the lower branches from the base of the tree prior to spraying should increase the effectiveness of the application and create warm, unfavorable conditions to the spruce beetle.

Pheromones

Pheromones, or message bearing chemicals, are emitted by the spruce beetle and serve to coordinate and regulate their attack behavior. Synthetic versions of these chemicals are available that either attract or repel spruce beetles. Synthetic pheromone production and pheromone dissemination methods need to be improved to take full advantage of pheromone technology. In addition, variation in results of operational synthetic pheromone use indicate that we do not fully understand regional variations in the chemical components of spruce beetle pheromones and the role(s) played by host volatiles. A summary discussion of operational and potential spruce beetle pheromone uses with literature citations was provided by Skillen et al. (1997). Operational uses of spruce beetle pheromones at present include trap out and attack disruption. However, results are inconsistent.

The trap out tactic uses attractant pheromones to lure spruce beetles into traps or trap trees and thereby reduce beetle populations to a more acceptable level. This would work best in isolated, lower level beetle populations where immigration would not erase the impact of trapping. Treatment trials using this have shown that the synthetic attractant pheromones do not compete well with natural attractant pheromones and may have varying attractiveness, as currently formulated, in every region of the spruce beetle range. However, the trap-out tactic has been successful on isolated populations in Utah as part of an integrated strategy employing several tactics (Bentz and Munson 2000).

In general, the use of attractant pheromones does not constitute a treatment tactic on its own, but is employed to augment silvicultural treatments or trap tree methods. For example, to retain or bring beetles into an area scheduled for a regeneration cut, one could place tree baits in the stand to be treated. Similarly, one can place tree baits containing attractant pheromone on trap trees or lethal trap trees to render them more attractive. It must be stressed that spillover attacks on trees adjacent to those baited is a common occurrence. Failure to treat baited and adjacent attacked trees in a timely manner can lead to exceptionally high tree mortality.

Deploying the spruce beetles' repellent pheromone prior to the attack period might reduce tree mortality from spruce beetle. The natural repellent pheromone or anti-aggregant pheromone of the spruce beetle is MCH or 3,2-MCH (3-methyl - 2-cyclohexen - 1-one). As colonization of a tree proceeds, the amount of MCH released into the air increases. Apparently, a certain threshold of MCH signals to other beetles that the tree is fully occupied and no longer suitable for colonization. Beetles searching for host material are thus repelled by such trees and search elsewhere for suitable material.

MCH has been used successfully to disrupt attack and colonization by spruce beetle in host trees and shown to reduce the attraction of spruce beetles on infested logs. In addition, MCH has recently been shown to be effective in preventing attack by Douglas-fir beetle (*Dendroctonus pseudotsugae*) on small, valuable stands of Douglas-fir. However, equivocal results in recent trials in Utah suggest that operational use of MCH against spruce beetle cannot be universally successful in all areas or.

A potential use of MCH would be to deploy MCH in an area in an attempt to disrupt attack and colonization there, causing dispersal of beetles. This would be done with methods similar to those used against Douglas-fir beetle. It may be that this tactic is only successful at lower beetle population levels and that effectiveness ceases above some population threshold. Another potential use of MCH would be deploying it to “push” spruce beetles from a stand or area needing protection while at the same time “pulling” them into a nearby stand or area scheduled for regeneration harvest with attractant pheromones. Neither of these tactics has been successfully demonstrated against spruce beetle as yet.

One inhibition to the development of operational MCH use has recently been eliminated. The USDA Forest Service under the authority of the US Environmental Protection Agency currently registers MCH for use in the United States. Not all States, however, have reviewed this recent development and given their approval against the Douglas-fir and spruce beetles.

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APPENDIX 2 ACTION ALTERNATIVES FOR MANAGING MOUNTAIN PINE BEETLE IMPACTS

W. C. Schaupp, Jr.

MANAGEMENT STRATEGIES

Several actions are available to reduce pine mortality which results from attack by mountain pine beetle (MPB), *Dendroctonus ponderosae* Hopkins (Order Coleoptera; Family Scolytidae). Indirect action can be taken toward the habitat and host trees required by MPB, while direct action can be taken against the MPB population itself. These pest management actions may focus upon reducing the number of susceptible pines and the overall susceptibility of stand conditions to MPB, upon eliminating infested trees and the MPB population directly or upon preventing new attacks. Indirect action addresses the "cause" of MPB outbreaks, which is the presence of susceptible pine stands, while direct action addresses the "symptom" of MPB outbreaks, which is too many beetles in one place at one time. Currently, there is no way to suppress a large-scale MPB epidemic once it has begun, although this is a theoretical possibility given unlimited funding and effort. Prevention should be emphasized where MPB impacts are undesirable. Altering stand conditions to be less favorable to MPB population increase and less susceptible to mortality from MPB is the only long-term "cure". Once undesirable MPB-caused mortality has begun, the intent of forest management should be to reduce adverse impacts to affected areas and minimize spread of the problem to adjacent stands. The decision to take a particular action(s) should be based on management objectives, economic factors, MPB population status and trends, stand conditions, location, resource values at risk, and other relevant issues. Consideration of MPB in the context of overall land management is important, for focusing on MPB alone may amplify other problems, such as dwarf mistletoe infestation. A combination of several of the following action alternatives may be useful in most situations.

ALTERNATIVE 1: DO NOTHING

Accept pine tree mortality and associated impacts caused by MPB as a natural phenomenon. MPB is a native insect that has been active for thousands of years. It is one of the most important biotic causes of pine mortality in conifer forests across the West. MPB populations increase or decrease without direct human influence. Epidemics of MPB have many ramifications in addition to the creation of dead pine trees. These impacts vary depending upon the extent, intensity, and duration of the MPB epidemic.

<u>Where to use</u> - Use where other alternative actions are not desired, cannot be implemented or will not be effective. One example would be designated wilderness areas.

<u>Advantages</u> - No mechanical site disturbance or introduction of foreign materials into the environment will occur. Understory vegetation will prosper. From extensive and intense MPB epidemics, water yield and possibly annual stream flow will increase. Tree regeneration may be facilitated by increased sunlight reaching the forest floor. Changes in vegetation and cover may be advantageous to certain wildlife species, particularly those which utilize dead trees. Successional trends may be affected advantageously. Public sentiment might be positively impacted by the decision to "let nature take it's course". Resources might be redirected toward areas where MPB impacts are undesirable, reducing future susceptibility to MPB, rather than "chasing beetles" where they are currently causing mortality.

Disadvantages - The "do nothing" alternative means human activity will not change the forest's resistance to MPB population increase and spread. Therefore, where MPB populations are increasing, doing nothing allows MPB populations to continue to increase and spread to additional trees and sites. Dead trees can become safety hazards over time as they rot and fall. Timber values are reduced or lost. From extensive and intense MPB epidemics, the following may occur: visual quality adversely affected by large numbers of dead and dying trees; travel restricted within affected stands by the eventual presence of fallen trees; fire hazard increased during the period when red, dry needles are present on recently killed pines; and, after killed trees have dropped their needles and rot and fall to the ground, more severe fires that are harder to manage. Loss of tree cover might lead to erosion or landslide once the tree roots have rotted. Tree regeneration may be inhibited due to loss of seed-bearing pines, the shading and covering effect of dead and fallen trees, and a lack of seedbed preparation. Changes in vegetation and cover may not be advantageous to certain wildlife species. Successional trends may be affected disadvantageously. Public sentiment may be negatively impacted, even in situations where an MPB epidemic can not be stopped by direct action.

ALTERNATIVE 2: SILVICULTURAL TREATMENT

Actions which promote tree vigor and wide spacing are the primary means to reduce or prevent the impact of MPB epidemics. The best long-term tactic to minimize losses to MPB is partially cut susceptible stands or harvest and subsequently replace susceptible stands. Removal of individual pines of low vigor and poor health will lessen the chance that MPB may get started in an area. Highly hazardous conditions for MPB in lodgepole pine stands are those at lower elevation-latitudes where average tree diameter exceeds 8 inches and average tree age exceeds 80 years; highly hazardous conditions for MPB in ponderosa pine stands are those where average tree diameter is equal to or greater than 8 inches and basal area is greater than or equal to 120 square feet. Therefore, partial cutting that reduces stands to 60 - 80 square feet of basal area or less and average tree diameter to below 8 inches affords the greatest protection. When partially cutting (thinning) susceptible stands, care must be taken to avoid leaving dense pockets of mature pines, because these areas can serve as foci for MPB attack. Cutting trees already killed by MPB is called "salvage harvesting" and is discussed under Alternative 3.

Where to use - This is a preventive treatment that addresses long-term tree and stand health. It should be incorporated into land management activity wherever MPB impacts are considered undesirable or are to be minimized. It is particularly important where timber values are the highest priority.

Advantages - Silvicultural treatment reduces the susceptibility of trees and stands to MPB attack and has been shown to limit pine mortality from MPB in stands. While this does not guarantee immunity from MPB infestation, it promotes tree and stand health and creates conditions known to be less favorable to MPB. Cutting green trees prior to MPB infestation maximizes economic return from timber resources, because MPB-killed trees are usually less valuable. If applied on a landscape scale, silvicultural treatments could result in a mosaic of susceptibility to MPB, which theoretically might inhibit the development of large-scale MPB epidemics by increasing MPB mortality as they seek new stands to infest. Landscape disturbance and renewal is inevitable in pine forests. MPB epidemics and stand replacing fires tend to create vegetation patterns that are very different from the results of most silvicultural treatments. Silvicultural treatment offers the opportunity to create vegetation patterns and stand conditions that may be more consistent with land management objectives than the results of an MPB epidemic and/or stand replacing fire. To rephrase this last sentence more directly and simply, `Who will select the trees that will die --- the forest manager or the beetles and fires ?'

Disadvantages - This action is not suitable for areas where tree cutting is undesirable, unaffordable or not allowed. Examples of such areas are wilderness, steep slopes, and areas where the visual quality of cut areas would be lower than that of dead trees. It is not possible in areas with no loggers and/or ready market for wood products.

ALTERNATIVE 3: SANITATION AND SALVAGE HARVESTING

Sanitation harvesting is a treatment applied to currently infested pine stands. Green trees with immature MPB developing under the bark are cut and either removed to an area at least one mile from other, susceptible pines or processed at a mill prior to MPB emergence. This makes it impossible for the MPB living within the infested trees to mature, emerge, and attack uninfested pines. Because MPB emergence can begin as early as mid-July; sanitation must be completed prior to MPB emergence to be effective. Salvage harvesting is cutting pines already killed by MPB from which the beetles have departed. This so frequently occurs in conjunction with sanitation that the tactics are combined under this alternative, although salvage harvesting does not affect the MPB population directly. The removal of currently infested and recently killed pines in a stand can serve as a starting point for a silvicultural treatment (see Alternative 2), as it will reduce the basal area and tree diameter in the infested patches.

Where to use - Use in stands that are currently under attack where reduction of the MPB population and recovery of timber resource values is desirable and where timber harvesting activity is acceptable. Especially appropriate are infested stands in proximity to uninfested, susceptible stands of high value where mortality from MPB would threaten land management objectives. Employ concurrently with silvicultural treatment in stands where the MPB population has not yet reached serious epidemic levels.

Advantages - MPB populations can be significantly reduced in localized areas and in stands by removing most or all infested trees prior to the emergence of the next generation of beetles. Sanitation provides a degree of protection to surrounding, uninfested trees and stands by removing a nearby source of attacking beetles. Timber volume is recovered that would otherwise be lost. The fire hazard which would result from the presence of dead pines holding dry, red needles is lowered. By limiting the creation of dead trees that will eventually rot and fall to the ground, the potential for severe fires that are harder to manage is lessened. The visual impact of dead and dying trees is reduced. The subsequent hazard from falling trees is lowered. Pine regeneration will be encouraged by both the site disturbance and the reduction in shade.

Disadvantages - There is little time for implementation, because infested trees must be removed by mid-July in the year following attack by MPB. Sanitation/salvage harvesting has not been demonstrated to suppress MPB populations on a scale larger than the individual stand, though this may occur in some cases. It should not be considered an efficacious control tactic across large landscapes or during severe MPB epidemics where MPB immigration into treated stands is likely. Sanitation/salvage harvesting undertaken without additional considerations for stand health and survival can lead to residual conditions that have other significant problems, such as increased spread and intensification of dwarf mistletoe. Individual infested trees must be identified and, in erring on the side of caution, trees which were unsuccessfully attacked that might otherwise survive will be targeted for cutting. Application may remove tree cover in spots or at densities that may be considered aesthetically unacceptable. Adverse site and soil disturbance is possible. Local mills and markets can be swamped by a sudden glut of wood.

ALTERNATIVE 4: INFESTED TREE TREATMENT

Cut and individually treat infested pines prior to the maturation and emergence of MPB, which can begin as early as mid-July. Any action that kills most or all of the MPB within infested trees prior to MPB emergence falls under this direct control action alternative. **The following examples do not work in all situations and are not all supported by rigorous research results.** Examples of infested tree treatment techniques are as follows: (1) Cut and burn on site; (2) Cut and bury at least 6 inches deep on site; (3) Cut and chip; (4) Cut and remove the bark from infested portions of logs before the immature MPB transform to adult beetles; (5) Cut and expose to direct sunlight such that the trunk surface receives sufficient heat to kill the beetles under the bark, rotating the trunk to ensure complete exposure; (6) Cut and cover with thick clear plastic such that the trunk surface receives sufficient heat to kill the beetles under the bark; (7) Cut and treat infested logs with an approved, registered insecticide in accordance with label directions [NOTE: Currently, only a few formulations of lindane, usually labelled as some brand of `borer spray', remain available to treat infested logs; it is increasingly difficult to locate such formulations of lindane in Colorado; and it is expected that, once current stockpiles are depleted, the manufacturer(s) will not produce additional supplies and the manufacturer(s) will not attempt to reregister these formulations of lindane with the United States Environmental Protection Agency for use by private citizens after their current registration expires]. It is important to check any treatment near the end of June. If excessive MPB survival is noted, option (7), chemical treatment, could still be performed to prevent MPB emergence. Infested tree treatment differs from sanitation harvesting (Alternative 3) only because it is usually applied on a smaller scale and is often not conducted in conjunction with salvage harvesting.

<u>Where to use</u> - This alternative is most appropriate for treating small spots in areas of great concern, such as those adjacent to residences and within developed recreation sites. It may also be appropriate in unroaded areas, on slopes too steep to harvest with conventional methods, in areas where the disturbance from conventional harvest activity is unacceptable, and in areas where there is no possibility of sanitation/salvage harvesting due to insufficient volume, no bids or other reasons.

<u>Advantages</u> - Much of the immature MPB population can be eliminated from the treated area. As a result, infested tree treatment provides a degree of protection to surrounding, uninfested trees and stands by removing a nearby source of attacking beetles. This temporary protection period can be used to advantage if silvicultural treatment is then implemented. The potential for site and soil disturbance is less than that of Alternative 3. The fire ignition hazard from the presence of dead pines holding dry, red needles is lowered. The visual impact of dead and dying trees is reduced. The subsequent hazard from falling trees is lowered. Pine regeneration may be encouraged by the reduction in shade. Firewood may be recovered from this treatment.

<u>Disadvantages</u> - There is little time for implementation, because infested trees must be removed by mid-July to August in the year following attack by MPB. Although a degree of protection is provided by this treatment, it is an action that kills beetles; the issue of mitigating the susceptible forest condition that lead to an MPB infestation is not addressed. Individual tree treatment is not a stand treatment and does not address any considerations for improving stand health. Individual tree treatment is unlikely to be implemented at a sufficiently large scale to be an effective control tactic across large landscapes or during severe MPB epidemics where MPB immigration into treated areas is likely. Infested trees must be individually identified and, in erring on the side of caution, trees which were unsuccessfully attacked that might otherwise survive may be targeted for treatment. Because it can be difficult to locate and treat absolutely all infested trees in an area, additional follow-up treatments may be needed in subsequent years. Infested trees may be

moved inadvertently as firewood prior to MPB emergence, possibly spreading the infestation. The cost of pesticides can be significant. Potential environmental hazards exist from improper use, storage or disposal of chemicals and chemically treated wood.

ALTERNATIVE 5: PROTECTION OF HIGH VALUE TREES

Prior to the attack period of MPB, which can begin as early as mid-July, the stems of living, green, uninfested trees which are of high value are sprayed with an approved, labelled insecticide that repels and/or kills attacking MPB and prevents infestation.

Where to use - This action is appropriate around private homes and in and around campgrounds and developed recreation sites when there is a threat due to active MPB populations in the vicinity. Trees must be of high value to justify the expense of spraying. Because specialized equipment may be required, trees must be relatively accessible. This action is not effective for trees which have already been infested by MPB.

Advantages - Controlled experiments and operational experiences have established this action as very effective in protecting individual pines from infestation. Specific formulations of carbaryl and permethrin are currently labelled for this use. Protection using carbaryl has been demonstrated to last from 10 - 18 months, meaning that a late spring application may afford two years of protection.

Disadvantages - Carbaryl and permethrin are toxic to insects other than MPB. Insecticide applied as protection does not effectively reduce the beetle population or address the cause of the outbreak. It does not guarantee absolute protection, especially if the application is not thorough and complete. It can be very expensive, especially if large areas require treatment, and is not likely to be employed over large areas for that reason. Potential environmental hazards exist from improper use, storage or disposal of chemicals and chemically treated wood. At the outset of MPB outbreaks, there may be a shortage of qualified applicators. Many citizens have concerns about environmental contamination and safety.